Climate-Smart Pest Management by Light Emitting Diodes (LEDs)

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المستخلص :

يتم تمييز العلاقة المتسقة بين النظم الزراعية مع بعض التغيرات المناخية من خلال نظام الانفوترونيك(Infotronic system) الذى أمكن استخدامه فى المكافحة الفيزيائية والبيولوجية لبعض الآفات مثل العنكبوت ذو البقعتين (*Tetranychus urticae*) بشكليه المورفولوجين،و دودة ورق القطن (*Spodoptera littoralis*)،ومنّ الخوخ(*Myzus persicae*)،و منّ القطن(*Aphis gossypii*). تم ذلك تلقائيا من خلال مساعد آلى متخصص للتحكم فى ألوان محددة للدايودات الباعثة للضوء (الليدات) والتى لها القدرة على احداث موت مباشر بنسبة تزيد عن ٦٠% أو عن طريق استدعاء المفترس المختص نسبيا لكل آفة. و قد سجلت المكافحة البيولوجية انخفاضا للآفات الزراعية بنسبة ١٠٠% فى بعض الحالات. وبالتالي ، فإن المعلومات التي تم جمعها والمتعلقة بتغيرات المناخ بواسطة أجهزة استشعار معينة كانت قادرة على السماح للنظام المدمج باختيار اللون المناسب ضد الآفة المعرضة للضوء وبالتالى استدعاء المفترس الصحيح المناسب لها أيضًا. تم تفسير النتائج بالاعتماد على معدل الخفض لنشاط انزيم أحادي أمين الأوكسيديز (MAO) فى الآفات التى تعرضت لليدات. ،ومن ثم أظهرت الدايودات الباعثة للضوء (الليدات) دلالة ناجحة كتقنية واعدة فعالة لادارة الآفات التى تكيفت مع التغيرات المناخية.

ABSTRACT:

Consistent relation is being distinguished between advanced agricultural systems with certain climate changes. Infotronic system was used to control some pests as *Tetranychus* *urticae* with its two morphs, *Spodoptera littoralis, Myzus persicae*, and *Aphis gossypii* physically and biologically. That was done automatically through an automated assistant to control specific colors of Light Emitting Diodes (LEDs) which were able to even caused direct mortality over 60%, or by calling particular predators to each pest. Biological control recorded in some cases 100% reduction of agricultural pests. Consequently, collected information related to climate changes by specific sensors were able to let the embedded system choosing the right color against the exposed pest and even to call the right predator also. Results were explained upon the reduction of monoamine oxidase (MAO) activity in the exposed pests to LEDs. Subsequently, light-emitting diodes (LEDs) demonstrated their successful significance as the promising pest management technology which adapted with climate changes effectively.

KEYWORDS: Biological control, Infotronic system, Light Emitting Diodes (LEDs).

INTRODUCTION:

United Nations targets for Sustainable Development Goals by 2030 (Envision 2030) consisted of 17 goals in which climate action is represented as one of them(United Nations 2018). Thus it is important to support adaptive capacity and resilience to climate changes by promoting mechanisms that are able to reduce and early warning for expected impacts to mitigate them. Moreover, providing facilities for effective climate change management will be helpful for developing countries specifically.

Furthermore, agricultural pests are usually controlled by chemical substances with their side effects on all components of the environment. Nonetheless, the utilization of physical treatment by exposure to light-emitting diodes (LEDs) is starting to take place in open fields or greenhouses against many pests. Certain LED colors have different effects on biomass and photosynthesis in plants. Blue LED was able to increase them by enhancing plant growth by optimization of photosynthesis through the control of chloroplast proteins while illumination with red and green did the opposite action (Muneer et al.,2014). All of these effects would appear indirectly further in the other connected chains which related to pests and their predators.

Agricultural infotronic framework (AIS) is an innovated framework which connections on-hardware sensors and embedded systems with electronic control units, and provided specific instructions in a system close to" plug-and-play" activity to the farmer (Zhang, 2010). That innovation is an ongoing propelled venture of accuracy farming. While exactness cultivating innovation has given ranchers intend to improve productivity and upgrading creation supportability, the blast of the measure of data should be overseen makes it hard for ranchers to adequately break down and use the data. The full framework could be built to control bothers under field conditions close to as an expansion of control pesticides against pests, pesticides' resistance and even biological control.

Precision farming can maximize farm efficiency and profitability by optimizing the production based on small grids of a field. However, it requires special skills and supporting information to synthesize the production information and develop plans for optimizing the production efficiency and profitability. Lack of tools for data analysis and production planning created an obstacle for producers who want to utilize their product information in planning their production. Consequently, the technical feasibility of precision farming has not yet been able to provide producers with economic benefits. A technology that "works" will not be adopted unless it is viewed as applicable by farmers and can be employed at a profit.

The full embedded system could control many tools under greenhouse conditions. LEDs were able to control mites directly and indirectly. Directly, both White and Blue LEDs caused 100% mortality against green and red types of *T.urticae*, respectively. All joined treatments of LEDs and Vertimec LC50 caused 100% mortality against both forms (Abd El-Wahab, 2015). Indirectly, LEDs successfully play an important role in mites control depending on its form biologically by the certain predator to each form (Abd El-Wahab and Abouhatab, 2014 and Abd El-Wahab and Bursic, 2014).

Deliberately, the present study of direct mortality percentages and effect of biological control against certain pests under greenhouse' conditions by LEDs colors, through an innovated instrument, was an addition of continuous chain of scientific research in the same target. Gained results were assessed and explained upon fundamentals of IPM and previous research in the field of control agricultural pests by LEDs.

MATERIALS AND METHODS:

1.Agricultural Infotronic System Components

Units of the innovated instrument were powered by solar energy mainly. Each unit was composed of 10 Watt monocrystalline solar panel - 14" X 12”, 20-foot/18-gauge cables, 12V/3aH 20-hour battery, and solar charge controller to protect the battery from overcharge / over-discharge.

All of the main components were connected with pyroelectric sensors which attached directly to the sensing camera according to Maulik (2012) with modifications to be suitable to specific device used in the present research and connected indirectly with traps and Light Emitting Diodes (LEDs) which were used to make the full required system. Then all pieces were embedded in the computer system.

Sensing camera was attached and used in a full circuit with a 12v relay switch was applied as a triggering circuit to provoke the camera when a 10v supply came from the voltage doubler circuit. The multiplier circuit doubled the incoming 5V signal to10v which then triggered the 12v relay switch to turn the CCD camera of the sensor node on and took images. The microcontroller, presented in Arduino Uno, would perform all the operations which were necessary to establish the communication with the BT (Bluetooth) module. In particular, the microcontroller was directing the BT module in a discoverable status and successively a master to slave connection was obtained between the sensor and a remote data acquisition station.

White and strong blue LEDs were used effectively. LEDs provided 12 h light/12 h dark photoperiod at the duration of exposure. Treatments were done under two different light colors with broad- spectrum-white LED and blue LED, Table (1) showed the wavelength and voltage drop of the used two colors of LEDs, but the control blocks were lightening by fluorescent light (Abd El-Wahab and Bursic 2014). Light quality and quantity were estimated using a Testo545 light meter (Testo, Germany). LEDs colors were used and controlled by Arduino Uno C++ language was used in the programming to On/Off lights automatically and also by Watson's assistant IBM.

Units with RGP placed, as one unit for treatment to direct control targeted pests and to specific predator to each pest as *Scolothrips sexmaculatus* and *Stethorus punctillum* , *Coccinella septempunctata* and *Chrysoperla carnea*, depending on last confirmed results of each predator's preference done by Abd El-Wahab and Abouhatab (2014).

The direct suction traps distributed in greenhouses' results were joined in the computer embedded system. Suction traps with motors were able to collect tiny insects and mites easily with the ability to further differentiate and count recorded automatically in the computerized system. Whenever results sent to the programmed system then it would be able to send orders to certain LEDs colors to be lighten depending on the target pest.

Table (1) Wavelengths of used Light Emitting Diodes (LEDs)

The Color	**Wavelength (nm)**	**Intensity 5mm LEDs**	**Fwd Voltage (Vf @ 20mA)**
Cool White	8000K	6000mcd @20mA	3.6
Super Blue	470	3000mcd @20mA	3.6

2.Crops in Greenhouses

Crops as strawberry, okra, apple, cotton, and potato were planted under greenhouses conditions. Mainly they were to examine the effect of LED colors through stable units of innovated instrument, to control certain agricultural pests. Each treatment was tripled and each replicate was constructed on $200m^2$. Besides so, separators were set among treatments to avert interactions among them. Exposure to certain colors was done for 12 hours for one week against specified insects and/or mites.

3.Predators Release

Collected local predators from different infested plants at Dakahlia District, Egypt, were reared under laboratory conditions. They were *S. sexmaculatus* and *S. punctatum*, *Coccinella septempunctata* and *Chrysoperla carnea*. Predators were released at targeted greenhouses and then predation was calculated as the percentage of biological control effect.

4.Counting of Pests

All insects and mites were checked after exposure to LEDs on all infested plants for one week. Thirty leaves were picked arbitrarily from every treatment and kept in paper sacks, and then transmitted to the laboratory, where they would be fixed by binocular. Predators' populaces also were checked on both surfaces of each leaf. Diminishment rates were evaluated by Henderson and Tilton (1955) total and occurred reduction was registered.

5.Monoamine Oxidase Inhibition

MAO-A is flavin adenine dinucleotide (FAD) containing enzymes that anchored to the mitochondrial outer membrane. MAO-A inhibition potency treatments were determined in the homogenates of each treatment. The rate of the MAO-catalyzed oxidation of Kynuramine was measured according to Aiyegoro and Van Dyk (2011). The yield of 4-hydroxyquinoline was the result of MAO-catalyzed oxidative deamination and subsequent ring. The concentrations of the fluorescent metabolite were determined by comparing the fluorescence emitted by the samples to that of known amounts of authentic 4-hydroxyquinoline at excitation (310 nm) and emission (400 nm) wavelengths. All enzymatic reactions were carried out to a final volume of 500 µL in potassium phosphate buffer and contained kynuramine as substrate, MAO-A (0.0075 mg/mL) and various concentrations of the test inhibitor (treatment). Stock solutions of the test inhibitors were prepared and then reactions were carried out for 20 min at 37°C and were terminated with the addition of 200 µL NaOH (2 N). Distilled water (1200 µL) was added to each reaction and then all were centrifuged for 10 min at 16000 × g. To determine the concentrations of the MAO-generated 4-hydroxyquinoline in the reactions, the fluorescence of the supernatant at an excitation wavelength of 310 nm and an emission wavelength of 400 nm was measured (Novaroli, et al. 2005).

6.Data Analysis

SPSS (V.16) was used to show differences among treatments exposed to certain LEDs compared with control.

RESULTS AND DISCUSSION:

Data revealed the interaction among LED colors, pests, predators, plants and eco-environment affected by changeable quantities and kinds of allelochemicals that emitted to join biological control mission officially. Table (2) showed that direct mortality and biological control percentages of both larval instars of *Spodoptera littoralis* were more sufficient by white LEDs than blue LEDs. The same trend was occurred in case of both species of aphids, *Aphis gossypii*, and *Myzus persicae* and also in case of green form of *Tetranychus urticae*. On the contrary, the red form of *Tetranychus urticae* was more affected by blue LEDs than white LEDs. declared the interaction among LED colors, crops, pests, and predators under quantities and qualities of allelochemicals released and then allowed to attract more numbers of predators able to reduce efficiency the pest' numbers.

1. **Effects of light emitting diodes (LEDs) against certain agricultural pests under changeable levels of CO2 and UV**

Therefore, resulted values were augmented in 2018 and conjugated with the increase of both UV level and CO2 ratio which compared with others in 2017 plus the exposure of certain colors of LEDs (Table 2). The significant difference appeared in 2017 through Kruskal Wallis Test (Chi-Square=5.33** for biological control effect and 3.00* for direct mortality). In addition, in 2018 through Kruskal Wallis Test (Chi-Square=4.82** for biological control effect and 4.03* for direct mortality). There was a highly significant difference upon Nonparametric Tests, Independent Samples Test showed that relation between direct mortality and colors was significant at 1%. Levene's Test for Equality of Variances recorded significant variables for both (F=.195** and t=4.74**). Besides so, the Reliability Statistics showed that (Cronbach's Alpha=.517*).

While relations among direct mortality of *Spodoptera* second larval instar, crops, and LED colors were determined through Mann-Whitney Test showed that Z=2.945* and Mann-Whitney U=3.94**. On the other hand, biological control showed that Z=1.47** and Mann-Whitney U=3.871**. Also, Runs Test of both colors and biological control was significant at 1% (Z=1.147**) and little significant appeared in case of colors and direct mortality relation at 5% (Z=.382*) for the fourth larval instar.

In addition, Table (2) showed the effect of certain colors of LEDs against aphids. In 2018 through Kruskal Wallis Test (Chi-Square=7.058** for biological control effect and 3.103* for direct mortality). There was a highly significant difference upon Nonparametric Tests, Independent Samples Test showed that the relation between direct mortality and colors was significant at 1%. Jonckheere-Terpstra Test showed that the highest significance was with Std. Deviation of J-T of biological control effect=6.023** while it was for direct mortality=6.245* in case of *Aphis gossypii* treatments. Moreover, one-way ANOVA showed that the highest significant differences were in case of results of biological control through exposure to cool white LEDs with F= 8.182** at 1% and strong blue LEDs F=3.481*.

Concerning the effect of LEDs on the two forms of *Tetranychus urticae* infested cowpea and strawberry, Table (2) showed that cool white color of LEDs was superior in its effect in case of green form and the strong blue color had the same effect in case of red form. Depending on Friedman Test and Kendall's W (Coefficient of Concordance= .751) recorded Chi-Square=21.032** among values of tested points by LED colors.

The most significant treatment was in case of exposure to cool white LED in the greenhouse cultivated with cowpea which infested with green form of *Tetranychus urticae* in 2017 and 2018, resp. Also based on Wilcoxon Signed Ranks Test (Z=1.501*). Pearson Correlations were significant when comparison was done among treatments in the biological control effect (.938**) and direct mortality (.935*) in both years.Depending on Friedman Test and Kendall's W (Coefficient of Concordance= .824) recorded Chi-Square=22.14**. The most significant treatment was in case of exposure to strong blue LED in the greenhouse cultivated with strawberry infested with red form of *Tetranychus urticae* in 2017 and 2018, resp. Pearson Correlation was significant when comparison was done among treatments in the biological control effect (.921**) and direct mortality (.900*).

Table (2) Effects of light emitting diodes (LEDs) against certain agricultural pests on different crops under changeable levels of CO2 and UV

Pests		The Crop	LEDs Colors	% Biological Control Effect	% Direct Mortality	% Biological Control Effect	% Direct Mortality
				2017		**2018**	
Spodoptera littoralis	Second Larval Instar	Cotton	Cool White	100a	٧٤.٣٣b	100a	٨٠.٧٧b
			Strong Blue	٩٦.٦٧a	٦٣.٣٣c	٩٩.٠٢a	c٧١.١٦
	Fourth Larval	Cotton	Cool White	٩٧.٠٢b	٧٠.٦٨c	١٠٠a	٨٥.٣١b

	Instar		Strong Blue	٩٣.٢٤c	٦٠.٣٩c	٩٦.١٩b	٧١.٠٨c
	Second Larval Instar	Potato	Cool White	٩٧.٣٥a	٧١.٦٩b	١٠٠a	٨٢.٣٧
			Strong Blue	٨٨.٢٩b	٦٥.٠٧c	٩١.٣١b	٧٤.٥٤
	Fourth Larval Instar	Potato	Cool White	٩٢.٣٨a	٦٦.٨١b	٩٧.٧٨a	٧٣.٤٢b
			Strong Blue	٨٤.٣٩b	٦٢.٣٤c	٩٠.٣٧b	٧٠.٢١c
Aphids	*Aphis gossypii*	Cotton	Cool White	١٠٠a	٧٢.٦٩b	١٠٠a	٨٠.٢٧b
			Strong Blue	٩٧.٨٩b	٦٥.٤٧c	٩٨.٤٧b	٦٩.٨١c
		Okra	Cool White	١٠٠a	٦٤.٢٨b	١٠٠a	٧٢.٢٤b
			Strong Blue	٩٢.٣٩b	٦٢.٧١c	٩٥.٠٢b	٦٧.٨٤c
	Myzus persicae	Potato	Cool White	٩٧.٦٥b	٧٠.٠٥c	١٠٠a	٨٢.٢٩b
			Strong Blue	٨٣.٦٨c	٦٢.٢٧b	٨٥.١١b	٧٥.٦١c
Mites	*Tetranychus urticae green form*	Cowpea	Cool White	١٠٠a	٨٤.٧١b	١٠٠a	٩٢.٠٤b
			Strong Blue	٩٥.٣٦b	٧٧.٩٨c	٩٧.٥٥b	٨٧.٥٢c
	Tetranychus urticae red form	Strawberry	Cool White	٩٠.٦٩b	٧٠.١١c	٩٢.٣b	٧٦.٢٤c
			Strong Blue	١٠٠a	٧٥.٤٨b	١٠٠a	٨٤.٣٨b
UV Index Average in 2017 (May-September)		**9.6**					
UV Index Average in 2018(May-September)		**10.8**					
CO2 Emission in		**218.31M**					

2017	
CO_2 Emission in 2017	**221.27M**

2. Monoamine Oxidase Inhibition

Effects of LEDs on Mono Amine Oxidases (MAO) inhibition of exposed pests were highly significant in general **(**Figures 1-4**).** Indeed, low activity of MAO activity was associated with accumulation of biogenic amines which played an important role to cause direct mortality or to attract specific predators to the exposed pest under certain colors of LEDs. Figure (1) showed that lower activity of MAO was occurred in case of exposed the second larval instar of *Spodoptera littoralis* on cotton to cool white LEDs (90.14%) and followed by which infested potato (85.01%) incomparable with control in 2018. While inhibition recorded 82.36 and 74.22% for the same instar under cool white LEDs for infested cotton and potato, respectively, in 2017.On the other hand, exposure to strong blue LEDs caused low inhibition of MAO with 83.22 and 67.24 % of the exposed second larval instar of *Spodoptera littoralis* on cotton and potato, respectively, in 2018. Therefore, inhibition recorded 71.34 and 53.22% for the same instar under cool white LEDs for infested cotton and potato, respectively, in 2017.Paired Samples Test recorded in 2017 t=3.582* between LEDs and t=3.776** in 2018. Cool white LEDs color was the highest significant in 2018 by one-way ANOVA (F=67.049**) incomparable with 2017 (F=37.978*). Therefore, Friedman Test showed that Chi-Square=16.966** was higher significant than strong blue LEDs treatments and the same trend was confirmed by Kendall's Coefficient of Concordance W[a] =.943**.

Figure (2) showed that lower activity of MAO was occurred in case of exposed the fourth larval instar of *Spodoptera littoralis* on cotton to cool white LEDs (85.54%) and followed by which infested potato (77.02%) incomparable with control in 2018. While inhibition recorded 75.36 and 68.24% for the same instar under cool white LEDs for infested cotton and potato, respectively, in 2017. On the other hand, exposure to strong blue LEDs caused low inhibition of MAO with 81.06 and 51.36 % of the exposed fourth larval instar of *Spodoptera littoralis* on cotton and potato, respectively, in 2018.

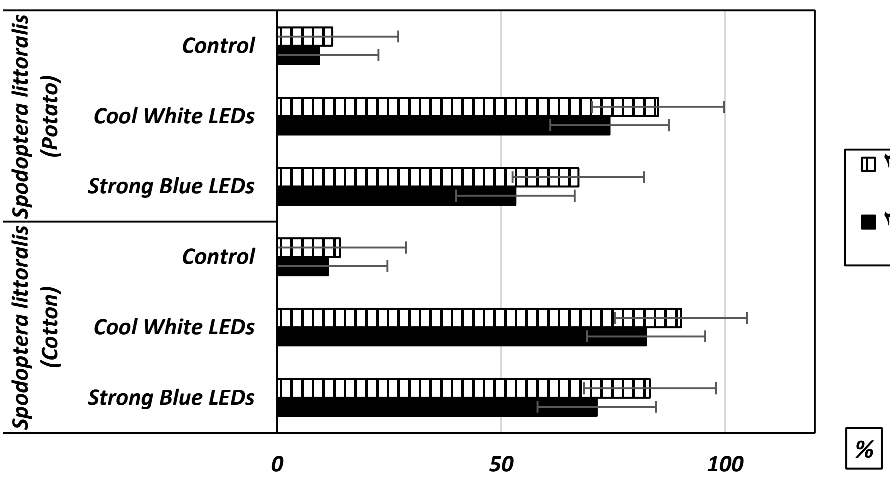

Figure (1) Inhibition ratio of Mono-Amine Oxidase Activity in 2nd Stage of *Spodoptera littoralis* after exposure to certain LEDs colors in 2017 and 2018

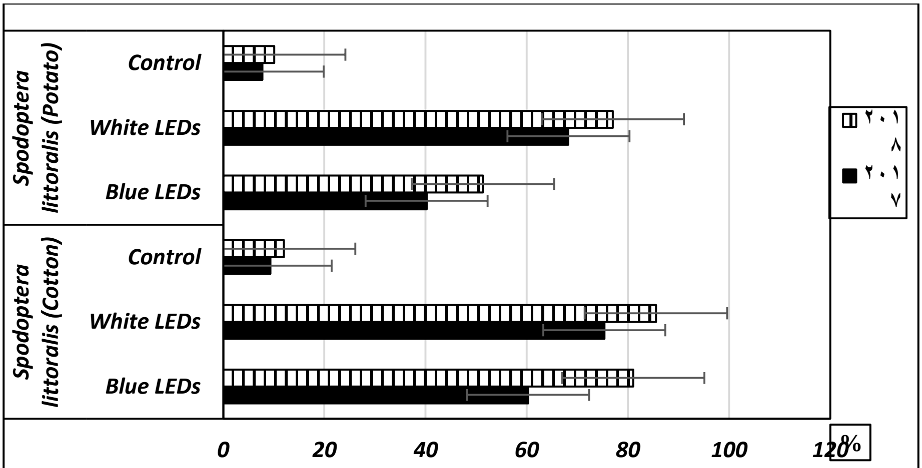

Figure (2) Inhibition ratio of of Mono-Amine Oxidase Activity in 4 th satge of *Spodoptera littoralis* after exposure to certain LEDs colors in 2017 and 2018

Therefore, inhibition recorded 60.28 and 40.22% for the same instar under white LEDs for infested cotton and potato, respectively, in 2017.Friedman test and Kendall's Wa showed that differences of LEDs'colors were more significant in 2018 with Chi-Square=16.97** than 2017. White LED's color was the highest significant in 2018 by one-way ANOVA (F=17.115**). Multiple comparisons tests detected that in 2017, LSD of strong blue LED was significant in comparison with control in both crops with mean difference=41.68* but cool white LED was higher with 63.23**. In 2018, LSD of strong blue LED was significantly incomparable with control in both crops with mean difference=55.15* but cool white LED was higher with 70.225**.

Likewise, figure (3) showed that the most effective LEDs color was cool white which reduced MAO activity in *Aaphis gossypii* infested cotton with 85.54 and 78.04, respectively, in 2018 and 2017. The same effect but with little difference occurred in the case of exposed *Myzus persicae* which infested potato to the cool white LEDs with 77.14 and 70.22%, respectively, in 2018 and 2017. Strong blue LEDs showed lower activity of MAO than cool white LEDs against aphids. The reduction was with 57.19 and 42.65 % in case of *A.gossypii* infested cotton in 2018 and 2017,resp. Moreover, MAO inhibited by exposure of *M.persicae* infested potato to blue LEDs with 72.44 and 61.02% in 2018 and 2017,resp.Results were more significant in 2018 through one-way ANOVA (F=44.861**) than 2017 (F=27.303*). Besides, effect of white LEDs was the most significant in 2018 than 2017, specifically on *A.gossypii* by Kendall's Wa =.907**. Therefore, paired-samples test showed that the total effect of LEDs was higher in 2018 (t=3.946* with Sig. (2-tailed) = .011) than 2017 (t=3.758* with Sig. (2-tailed) =.013).

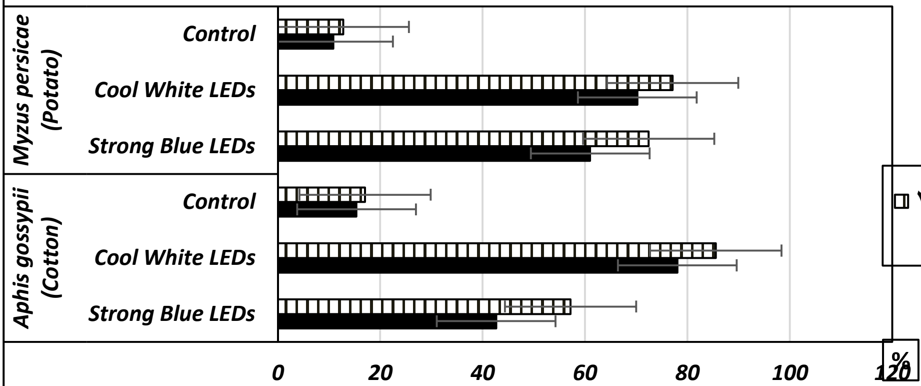

Figure (3) Reduction of Mono-Amine Oxidase Activity in *Aphis gossypii* and *Myzus persicae* after exposure to certain LEDs colors in 2017 and 2018

Consequently, figure (4) showed that higher inhibition of MAO was occurred in case of exposed the green form of *Tetranychus urticate***,** infested cowpea, to cool white LEDs (95.14 and 42.55%) in 2018 and 2017, respectively. Similarly, but with strong blue LED, the red form of *Tetranychus urticae* which infested strawberry, recorded 98.32 and 77.85% in 2018 and 2017, respectively. Correspondingly, blue LEDs caused a reduction of MAO activity with 62.7 and 45.39% of the green form of *T.urticae* infested cowpea for the same year's arrangements. Also, white LEDs caused reduction of MAO activity with 64.21 and 32.78% of the red form of *T.urticae* infested strawberry for the same year's arrangements. There were a significant difference = 0.28* at 95% among results of both years by Related samples Wilcoxon test. While results were most significant in 2018 with one-way ANOVA (F=67.049**).

Besides, Kendall's tau_b Correlation Coefficient=.894* between LEDs and both exposed forms of *Tetranychus* in 2017 while it was recorded in 2018 (.938**). In the same trend differences of forms were significant in both tested years 2017 and 2018 upon Kendall's tau_b Correlation Coefficient=1.00*.

Phototactic behavior of two predators, *Stethorus punctillum* and *Scolothrips sexmaculatus* was strongly affected by LEDs to the two forms of *Tetranychus urticae* was back mainly to LEDs colors (Abd El-Wahab and Abouhatab 2014). The highest attraction of *S.punctillium* recorded to *T.urticae* green form exposed to white LED while it was detected with *S.sexmaculatus* preyed on red form exposed to the blue LED. Concerning voracity, it was recorded 100 % in case of predation on the green and red forms of *T.urticae* exposed to white and blue LEDs by *Stethorus punctillum* and *Scolothrips sexmaculatus*, resp. These results could be explained upon important of MAO. The main mode of action is around reduction of MAO activity, therefore increased of biogenic amines, and elevated levels of ROS as a result of exposure of insects to certain colors of LEDs (Santos et al.,2013).

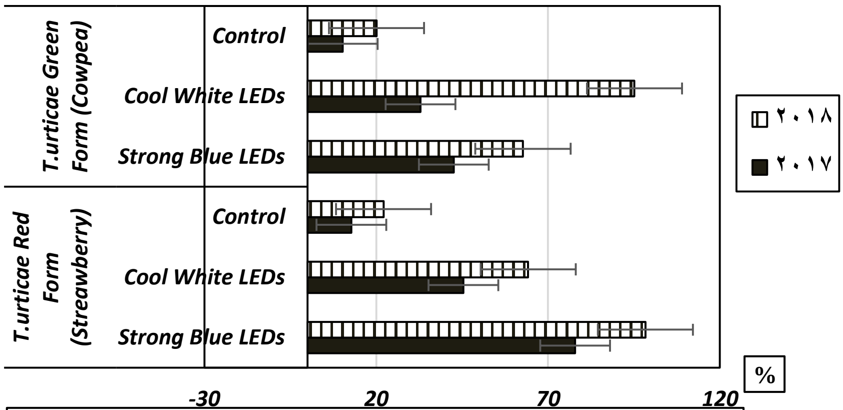

Figure (4) Inhibition ratio of of Mono-Amine Oxidase Activity in in both forms of *Tetranychus urticae* after exposure to certain LEDs colors in 2017 and 2018

The main results even from this paper or before studies in the same direction, all proved efficient effects of LED colors. The system was started with a simple stable unit and then being automated through Watson Assistant IBM which was helpful to be developed for any requirements.

LED colors were able to do certain functions and mainly degrees of blue and white colors. Blue color and UV-A caused indirect damage to DNA by upgrading the creation of reactive oxygen species (ROS), and increments in oxidative pressure (Meng et al.,2009; Sang et al.,2012). Blue short wavelengths were not in every case progressively dangerous but it could be more destructive than UV-A against insects (Hori et al.,2014).

Phloem-feeding pests which known for their “stealthy” feeding mechanisms that cause minimal damage to plant tissues as they establish direct nutritional access through the vascular tissue. To date, most studies of phloem-feeding insects have focused on the interactions of pests with their host plants (Moran and

Thompson, 2001 and Li et al.,2008). But more factors included effect of LEDs and attraction of natural enemies were effective in biological control equation. Furthermore, the direct positive phototaxis to each color of LEDs appeared clearly in case of certainly exposed morphs of *Tetranychus urticae*. Such exposure was so sufficient for the two expected responses, direct mortality and biological control by specific predators. Moreover, it was noticed that some lights were able to attract mites to go towards the apex of the plant stem and formed silk balls that would full of immatures and adults of mites before migration in the nick of time (Pralavorio et al.,1989). Photoreactivated *T. urticae* eggs and larvae were related mainly to phase-specific UVB vulnerability and outbreak symptoms due to UVB-induced DNA damage (Murata and Osakabe,2014).

Concerning UV radiations, the most point which all studies agree with that is related to the prscence of *T. urticae* on the undersides of leaves which possibly used as a filter to avoid the deleterious effects of UV-B. (Ohtsuka K. and Osakabe,2009 and Suzuki et al.,2009, 2014). Chosen sheltered areas because of low UV transmission through leaves as the accumulation of compounds that act as selective sunscreens (e.g., phenolics). Through presented study, there were noticeable adult females with orange body color in case of exposure to high UV and CO2.That could be explained by the accumulation of carotenoids, a scavenger for UV-induced reactive oxygen species (Abd El-Wahab and Taha,2014). Consequently, also the previous point clarified plainly the diverse reaction of every structure to blue and white LEDs.

It could be detected that increased atmospheric carbon dioxide affects plant photosynthesis and chemistry (Kimball,1986), thereby influencing plant tissue nutritive quantity and quality for arthropods.CO_2 enrichment effect studies showed different results winged between suppression of whiteflies on tomato (Tripp et al.,1992) and a noticeable increase of *Tetranychus urticae* populations on white clover (Heagle et al.,1994 and 2002). Whereas there were none significantly effects combined with the increase of CO_2 also noticed with thrips on milkweed (Hughes and Bazzaz, 1997) and both thrips (Butler, 1985), and whiteflies (Butler et al.1986) on the cotton host. On the other hand, many studies have evaluated the relationship between plant resistance and tolerance to herbivores (Bailey and Schweitzer, 2010 and Muola et al.,2010), but little information is available regarding how the relationship between tolerance and resistance is affected by abiotic stress such as global CO_2 enrichment. Some studies suggested that raised CO_2 diminished tomato plant resistance against *H. armigera* by causing suppression of the signal molecule jasmonic acid (JA) and JA-Pathway-related defensive enzymes as the most significant defense hormone involved in resistance against chewing insects. Tomato plants grown under ambient CO_2 are highly tolerant of *H.armigera* than others grown under elevated CO_2 (Guo et al.,2012). Phenotypic plasticity is a principal means by which plants cope with biotic or abiotic stress (Valladares et al.,2007), and the decreased resistance and tolerance to herbivores under elevated CO_2 recommends that raised CO_2 decreases the phenotypic versatility of plant reaction to herbivorous.

Even antagonistic relation was detected between both UV and CO_2 and pesticide resistance especially in tiny pests with little number of chromosomes that are capable to form multiple resistant effectively. Even with use with synergists to neutralize resistance in case of metabolic resistance, synergists loss their activity and being unstable under UV light (Savinelli 2014). Even pesticides' resistance elevation occurred in the case of exposed *T.urticae* to UV and CO2 could be explained in two ways, firstly depending on escaping to remaining sheltering with low amount of UV transmission on the lower leaf surfaces, then the oviposition and other physiological indexes would be affected slightly. Secondly, explained by the elevation of reactive oxygen scavengers (ROS) production as stress of Ultraviolet (UV) radiation which is able to eliminate reactive oxygen species. The most known elements of ROS in *Tetranychus urticae* are melatonin and arylalkylamine N-acetyltransferase (NAT), (Suzuki et al.,2008). Moreover, both environmental factors play an important role to decrease the concentration of sprayed pesticide under field conditions which lead to exposure of under lethal concentrations and contribute to resistance formation gradually. But LEDs were able to solve metabolic resistance also by reduction of reactive oxygen species and clear the site of action (Abd El-Wahab,2019).

CONCLUSION

Comparatively, conjugation of the capstone project for tech-smart with agricultural pests control is a good step for automated biological control. Notably, exposure to LEDs was able to do the required role even to cause direct mortality or to call the natural enemy for its prey. Predators were able to reach their prey which exposed to specific colors of LEDs, then accumulation of biogenic amines was picked by predators' olfaction sensors successfully.

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